Mem. Natl Inst. Polar Res., Spec. Issue, **54**, 337–341, 2001

Report

Greenland Sea in winter

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Abstract: The necessity to carry out observations in the Greenland Sea in winter is emphasized, and the background which makes such observations so important is described. Recent efforts are reported.

1. Introduction

Winter conditions in the Greenland Sea are poorly known. This short article points out that observation of the sea in the dark months is important.

Oceanic phenomena are inherently seasonal, so it is generally true that complete understanding requires observations in all seasons. In the Greenland Sea, however, a quite interesting additional motive for winter observation exists.

2. Role of the Greenland Sea

2.1. Arctic Ocean

The Arctic Ocean is one of the largest semi-closed marine basins in the world Ocean, together with the Mediterranean Sea. The basin is connected to the world ocean system through one channel/strait. The channel functions as a river mouth, while the basin itself is equivalent to the main river with a great width and small gradient, which gathers water from the tributaries, which in this case are ordinary rivers on land. The Greenland Sea is the river mouth. This simplified schemes "leaks" through Bering Strait, the Canadian Arctic Archipelago and the Barents Sea.

Figure 1 shows the Arctic Ocean drainage basin. It is a large drainage basin. The land area of the basin alone extends over 1548500 km^2, which exceeds one tenth of the entire land area of the earth. Ten percent of all precipitation falling on land would be collected in this basin, if precipitation were uniform worldwide. Furthermore, the precipitation in the basin has more or less uniform properties, as it falls under a unique physical environment, i.e. in the Arctic.

The Arctic Ocean supplies a large quantity of fresh water with particular characteristics to the global water circulation. Therefore hydrological investigation of the Arctic Ocean is necessary to clarify the structure and mechanism of the global water cycle.

2.2. Runoff

Discharge measurement at river mouths is one of the most important observation

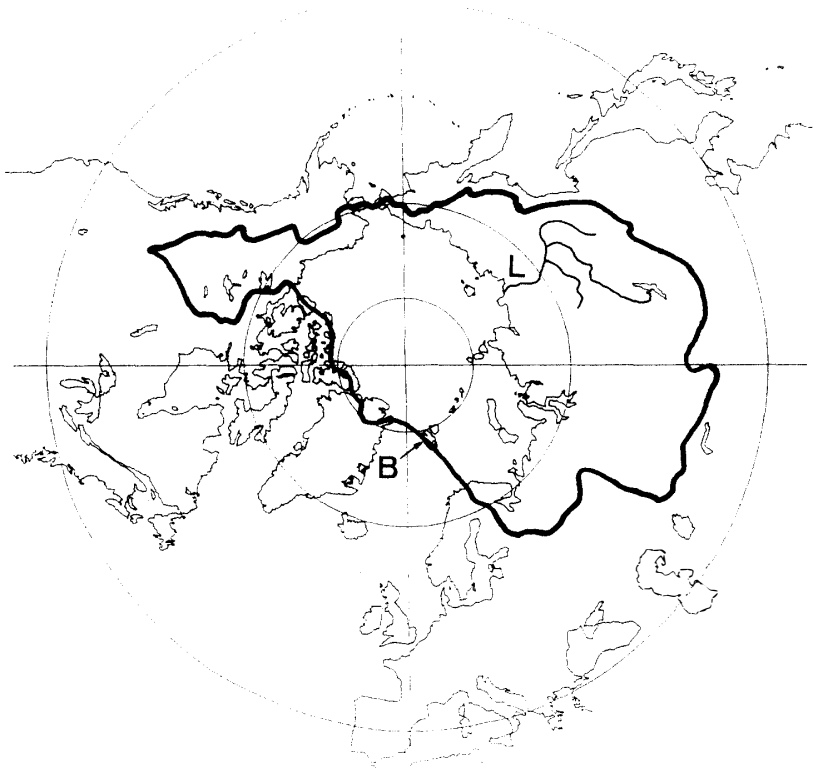

Fig. 1. Drainage basin of the Arctic Ocean.

components in hydrological research. Water behavior in the area of the Arctic "river mouth" (the Greenland Sea) is rather complicated, with currents flowing in two opposite directions simultaneously, from the Arctic Ocean to the Atlantic and vice versa. In the present study, the scheme is simplified. Streams at different depths and locations have different directions, into the basin and out of it. There must be a net runoff, which pumps out the net basin precipitation and keeps the water level of the basin unchanged. Part of the net runoff flows out of the basin at the surface, the rest finds its escape route at depth, analogous to ground water.

Assessment of the runoff is not easy. In contrast to its great width, the depth of the surface runoff is rather small, a couple of meters at most. Underneath the surface flow lies a thick layer of seawater. The "riverbed" in this case consists of water, not rock, and the river water penetrates into the "ground", *i.e.* into the seawater, without much difficulty and at any point. This makes measurement complicated in many ways. The worst complication is the difficulty in assessing the travel route of each water particle. The travel time since the particle left the land until it arrives at the "gauging station" in the Greenland Sea cannot be estimated with the desired accuracy.

Some discharge records are shown in Fig. 2. Two tributaries of the Arctic Ocean "River", the Lena in Russia and the Bay in Spitsbergen, are chosen. Among hundreds of rivers nourishing the Arctic Ocean, these two are not necessarily typical or representative in any sense. The selection of rivers is thus arbitrary. The observation years were also chosen arbitrarily. They present similar discharge patterns. Strong seasonal variation is noticed in

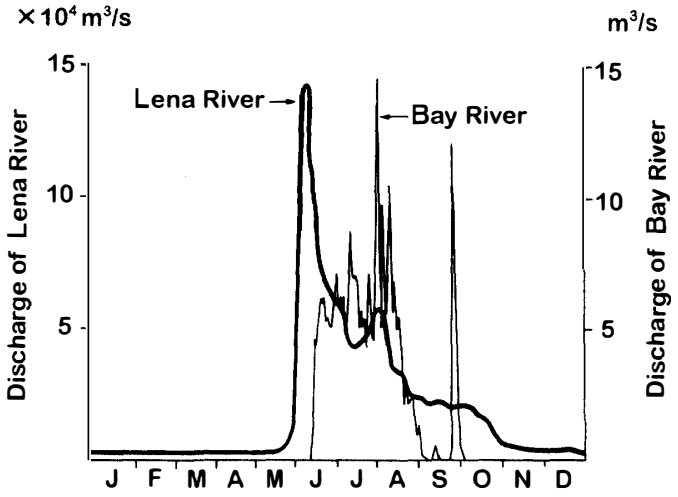

Fig. 2. Discharges of two Arctic rivers.
Positions of the gauging stations are indicated in Fig. 1 by L and B respectively. Thick curve: Lena River in 1958 (redrawn from Mostahov, 1972). Thin curve: Bay River in 1993 (drawn with the data collected by NVE, Norwegian Water Resources and Energy Administration). Letters on the abscissa stand for months, e.g. J for January, June or July.

both diagrams. The water properties are also expected to vary drastically with the season.

Each tributary has its own discharges; some of them may very similar by to that in Fig. 2. The sum of the tributary discharges, together with the net precipitation falling directly on the Arctic Ocean, will give the total discharge at the river mouth.

Tributaries are located at various distances from the river mouth, and the discharges from them arrive at the river mouth after different travel times. Some particles may stay quite long in the "river", perhaps even years or tens of years.

The summing of the discharge is, hence, far from simple. Let us consider the peak discharge of June, measured in the Greenland Sea. Only part of the water observed at the gauging station, would correspond to the annual peak discharges of tributaries. Thus, observations have to be made all year round, not only at the particular time of a year of immediate interest. Without winter observations, for instance, the full summer variation is not obtained either. Year-round observation in the Greenland Sea is the only way to investigate the full annual water cycle of the Arctic Ocean.

3. Field observations

3.1. Past studies

The northern Greenland Sea has been observed intensively in recent decades, mainly by European oceanographers. Most of the observations were, however, carried out in summer. Among a rather large volume of publications two are mentioned here: one of the oldest modern investigation (Muench *et al.*, 1987) and one involving the author directly (Ito *et al.*, 1994).

Norwegian fishing boats go up as far north as 81 degrees in winter every year. They must have made some measurements for their own purposes but the data are not in the

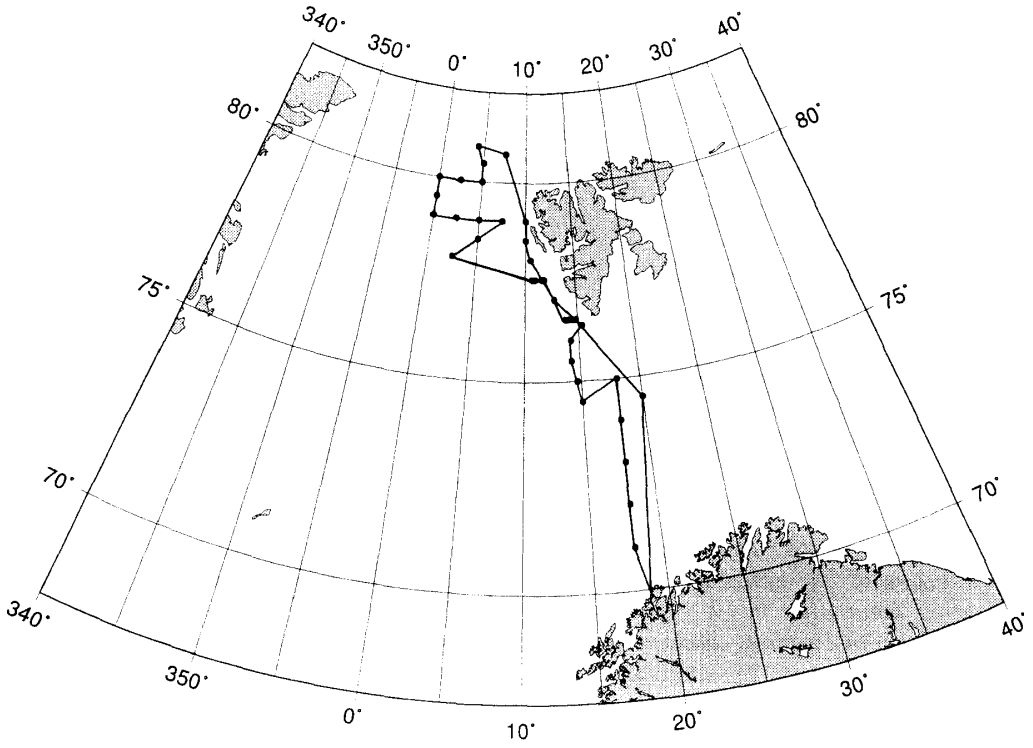

Fig. 3. Cruise route of the Ivan Petrov, January 1999. Black circles show locations of oceanographic stations.

public domain. The present author has requested to use one of the boats as an observation platform, but was refused.

Russian boats may also have sailed in the Greenland Sea in winter, either for fishing or for other (perhaps naval) purposes, and may have possibly collected some data. Access to their data is also difficult.

The research vessel Jan Mayen sailed to Isfjorden/Kongsfjorden in December 1994. Although the cruise was limited to the fjords and along the coast of Spitsbergen, this was the only modern winter expedition focused on oceanographic observations up to the last two years. The data obtained are kept in UNIS, University System of Svalbard (Vigdis Tverberg, personal communication).

3.2. Recent years

A Japanese-Russian joint cruise was conducted using a Russian vessel Ivan Petrov in January 1999 in the Greenland Sea. The cruise report has been published (Ito, 1999) and only the cruise route with stations is given here (Fig. 3). Research results are not presented in either the report or in the present article. Some of the cruise participants present their results in this Symposium Proceedings, and others are preparing for later opportunities.

Two research cruises were carried out in February in the Greenland Sea, in 1999 and in 2000 by the Norwegian Polar Research Institute, Tromsø and Scott Polar Research Institute, Cambridge, respectively. The results will be reported by the respective institutions. Hopefully, these recent cruise are a sign that winter research in the Greenland Sea is finally

starting to attract attention.

References

Ito, H. (1999): Cruise Observations in the Greenland Sea and Barents Sea, January 1999. Nankyoku Shiryô (Antarct. Rec.), **43**, 361–365.

Ito, H., Osterhus, S. and Ushio, S. (1994): Temperature Profiles of the Greenland Sea in the Summer of 1993: Oceanographic Observation on the R/V Lance Cruise. Nankyoku Shiryô (Antarct. Rec.), **38**, 68–71.

Mostahov, S.E. (1972): Reka Lena (Lena River). Yakutsk, Yakutskoe Kniznoe Izdatelctvo, 144 p. (in Russian).

Muench, R.D., Martin, S. and Overland, J.E., ed. (1987): MIZEX special issue. J. Geophys. Res., **92** (C7), 6715–7225.

(Received May 30, 2000; Revised manuscript accepted July 21, 2000)